ITER Impact
on Technology for the Fusion Industry

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The impact of the international ITER project on US capabilities in fusion science and technology is diverse and deep. To achieve a reactor-scale burning plasma producing 500 MW of fusion power, ITER required the development and/or advancement of a variety of technologies. US engagement in ITER results in significant benefits to US fusion including technologies, know-how, and experience. ITER will deliver a scientific understanding of burning plasmas, an essential step in the development of an economical fusion power plant.

The following technology areas are directly beneficial to the US fusion industry:

Tools and Strategies for Plasma Control and Performance

ITER's burning plasma operation will demonstrate and optimize plasma power handling control. ITER has led to advances in modeling, prediction, avoidance and control of plasma transients and disruptions in tokamaks; supporting technologies and techniques have also been developed. Non-tokamak fusion devices can also benefit from the improved understanding of plasma behavior derived from ITER R&D.

Superconducting Magnet Technologies

ITER project needs inspired global industry to support an eight-year campaign to produce 200 kilometers of cable-in-conduit superconductor. While next generation magnetic fusion devices will seek to take advantage of new high temperature superconductor materials or advanced low temperature materials and designs, the industry lessons from the ITER ramp-up remain relevant. In addition, the complexity and scale of ITER magnet systems can inform solutions for other magnetic devices, from feeders and joints to production and testing strategies.

Radiation Transport Analysis

Higher resolution and faster radiation analysis tools have been applied to understanding ITER shielding and safety requirements, including shutdown dose rates. These tools, combined with advanced modeling and simulation, will be highly relevant to the design, qualification, and safe operation of future fusion devices and power plants.

Superconducting magnet module in fabrication for ITER. Photo: GA

High-Powered Plasma Heating

To achieve sustained fusion power, plasmas must first be heated to extreme temperatures (100+ million degrees C). State-of-the-art technologies were developed for ITER in radiofrequency (RF), microwave and neutral beam heating. Many industry fusion configurations rely on a dependable high-powered plasma heating technology.

Continuous Plasma Fueling

ITER has led the development of continuous pellet fueling systems for long pulse operations. Pellet fueling is an effective strategy for efficiently and reliably delivering hydrogen fuels to plasmas in various device configurations, including many of those proposed by private fusion ventures.

Fusion Materials

ITER-scale requirements drove a demonstration path for the development and selection of appropriate plasma-facing and divertor materials that can handle the neutrons, magnetic fields, and heat flux of the ITER fusion environment. The materials work done for ITER provides a foundation that next generation fusion devices and fusion power plants can build on for materials development and qualification activities to assure components are ready to perform in even harsher nuclear conditions.

Fusion Power Handling

ITER power levels and pulse length will exceed that of any current fusion device. Going forward, the power handling demands of a fusion power plant designs will require full steady state operation solutions. R&D for ITER informs research for next generation devices and commercial fusion reactors on plasma-device wall interactions and power exhaust handling.

Tritium Processing

Nearly every fusion industry concept assumes a reliable source of tritium. Although ITER will not breed its own tritium for its operation, ITER will include a set of “test blankets” that contribute to the development of tritium breeding blanket technology.

Component for high-powered microwave plasma heating system. Photo: US ITER/ORNL

Vacuum Technology Advancement

ITER has the largest plasma volume of any fusion device (840 m^3) and is the largest vacuum vessel ever constructed. High-speed, tritium-compatible pumps have been developed for the ITER tokamak. Industry-proposed fusion devices also require exceptional vacuum environments, to assure a high performance plasma environment and to support tritium processing.

Remote Handling Technology

For ITER operation and maintenance, remote handling technologies were developed for divertor cassettes and blanket modules. Other fusion devices and future power plants can build off these robotics technologies to meet operations, testing and maintenance needs.

Diagnostics for Extreme Environments

ITER plasma performance and control diagnostic systems must perform in extreme nuclear fusion environments with a high degree of reliability. Given that diagnostics are essential to both operations and extending plasma performance, developments from ITER instrumentation systems will contribute to the safe and efficient operation of other high-power fusion devices and ultimately a fusion power plant.